The influence of the industrial complex on the atmospheric air in the Sverdlovsk region

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The influence of the industrial complex on the atmospheric air in the Sverdlovsk region

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Abstract. The work is dedicated to studying the level dynamics of polluting substances emissions into the atmosphere of Yekaterinburg city and the Sverdlovsk region in the period of 2012–2016. In the process of our work we found out an insignificant reduction of main indicators values such as SI, HR, and IPA to estimate the atmospheric air quality. Nevertheless, the level of the air pollution in Yekaterinburg city remained high in the stated period. We also suggested some methods to reduce enterprises emissions in the article, which will lead to improving the air quality. In the result of our work it was established that the main pollutants are suspended particles, nitrogen dioxides, phenol, and benzene. Moreover, the connection between the atmospheric air pollution degree and the Sverdlovsk region population's health was determined.
Key words: atmospheric air, environment, pollutants, TLV, industrial complex, population morbidity

1. Introduction

At present, the Earth's biosphere is constantly exposed to increasing anthropogenic impact. Chemical pollution of the environment is the largest impact and is due to the release of non-natural substances into the atmosphere, hydrosphere and lithosphere. Thus, gaseous and aerosol pollutants of industrial origin enter the atmosphere. The content of carbon dioxide continues to grow, which contributes to the increase in the average annual temperature on our planet. The consequences of human impact on the environment are the focus of environmentalists around the world, as they are the cause of such global problems as the "greenhouse effect", the destruction of the ozone layer, acid rain [1–8].

Industrial regions are the main sources of air pollution. The greatest contribution is made by North America, East Asia and Europe. They account for more than a half of all pollutants which are emitted into the atmosphere. In large cities, there is an environmental problem associated with an increased threshold limit value (TLV) of harmful substances in the air. In Russia these are Moscow, St. Petersburg, Samara, Chelyabinsk, Yekaterinburg and others.

Pollution of the atmosphere also affects the human body, especially the respiratory system. The natural resistance to diseases decreases due to harmful secondary health effects [9–15].

Thus, the current problem of the global scale is the organization of control over atmospheric pollution on the one hand and the limitation of hazardous emissions by industrial enterprises and motor vehicles, on the other.

2. Methods

Data acquisition on environmental pollution is carried out during the monitoring of pollution on the basis of the state observation network. In our work we have analyzed the data of state reports on air pollution in the Sverdlovsk region cities in 2012–2016.

Three main indicators are used to assess air quality:

1. SI, dimensionless – the standard index, the largest impurity concentration measured during the considered period of time, which is divided by the corresponding value of the TLV, from measurements at the post for one impurity, or at all posts after one impurity, or at all posts for all admixtures.
2. HR, % – the highest repeatability of exceeding the TLV from measurements at the post for one impurity, or at all posts for one impurity, or at all posts for all impurities.
3. IPA, dimensionless – a complex index of air pollution in five priority substances, which determines the state of atmospheric pollution in the city (it is defined as the sum of single pollution indices of the five priority pollutants reduced to the harmfulness of sulfur dioxide).

Assessment of the level of air pollution is carried out in four categories: low, heightened, high and very high. The level of atmospheric air pollution in the city is determined by the maximum value of one of the three criteria: SI, HR, and IPA.

We have analyzed the changes in the level of air pollution by the main pollutants such as suspended particles, nitrogen dioxides, phenol, and benzene. On the base of the obtained data we have plotted corresponding diagrams, graphs and schemes, which let us present the found correlations visually.

3. Results and discussion

The Sverdlovsk region is one of the largest industrial centers of Russia. Therefore, human economic activity has a very significant impact on the environment including the atmosphere. State supervision in order to monitor human activity and prevent abuse in the sphere of nature management in the Sverdlovsk region is carried out [16–18]. This supervision is represented by:

- The Department of the Federal Supervisory Natural Resources Management Service in the Urals Federal District;
- Ministry of Natural Resources and Environment of the Sverdlovsk Region;
- The Ural Department of the Federal Environmental, Industrial and Nuclear Supervision Service of Russia;
- The prosecutor's office, etc.

Adherence to standards and laws in the field of the environment provides many benefits, including savings, for example, no costs to pay fines for environmental pollution; reduction in the number of payments to employees on sick leave due to reduced morbidity. The other benefit is an increase in the company's income, namely an increase in the number of potential customers of the company's products and a positive image of the enterprise, which cares about its personnel and consumers. The most important result is an improvement of the overall environmental situation on the territory near the enterprise and therefore an increase in the number of people who move to this area for permanent residence.

Criminal, administrative, civil, disciplinary and special sanctions depending on the degree of public danger are provided for offense of the environmental legislation [19–23].

At present time, the main stationary sources of pollution on the territory of the Sverdlovsk region are located in such cities as Yekaterinburg, Nizhny Tagil, Kamensk-Uralskiy, Pervouralsk, etc. The quality of atmospheric air in the region is determined by the emissions of pollutants from stationary mobile sources (motor transport) (figure 1):

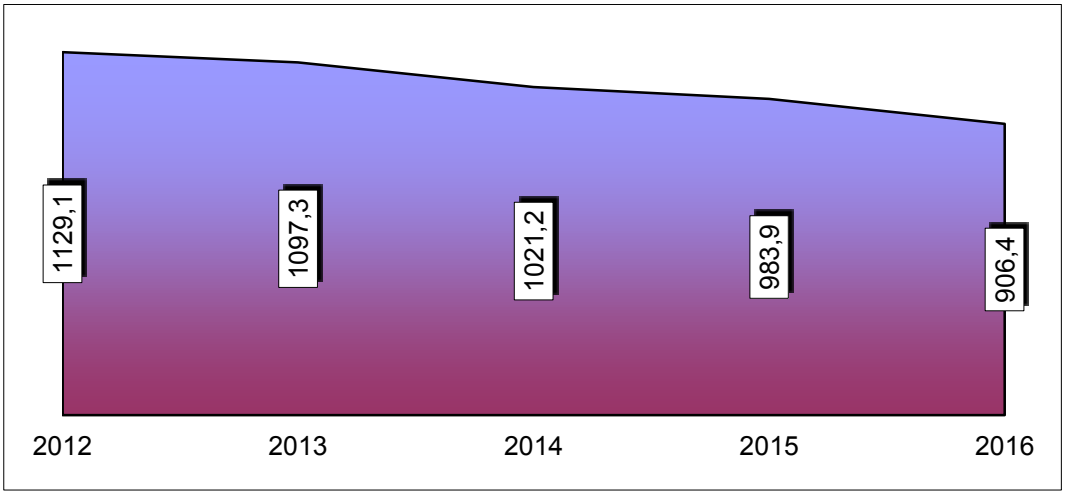

Figure 1. Emissions of pollutants from stationary sources, thousand tons [17]

In 2016 (in compare to 2015) emissions of pollutants into atmospheric air from stationary sources were decreased by 77.5 thousand tons (7.9 %), including solids – 33.9 thousand tons (20.4 %); emissions of liquid and gas-different substances – 43.6 thousand tons (5.3 %), including reduction of emissions of sulfur dioxide – 28.9 thousand tons (10.9 %); nitrogen oxides – 10.4 thousand tons (7.1 %); volatile organic compounds – 1.2 thousand tons (10.8 %); hydrocarbons – 3 thousand tons (2.4 %), and carbon oxide – 0.6 thousand tons (0.2 %).

The decrease in the total amount of air emissions was mainly due to a decrease in electricity generation, fuel consumption, decrease in production at a number of enterprises, reduction in the volume of repair work on the linear parts of the main gas pipelines, and the implementation of environmental measures. Emissions of pollutants into the air in the Sverdlovsk region were decreased by 222.7 thousand tons (19.7 %) in compare to 2012.

3.1. Enterprises and their contribution to air pollution

The diagram (figure 2) presents a list of stationary sources that contributed mainly to air pollution on the territory of the Sverdlovsk region in 2016 (81.4 % of the total emission in the region) [17].

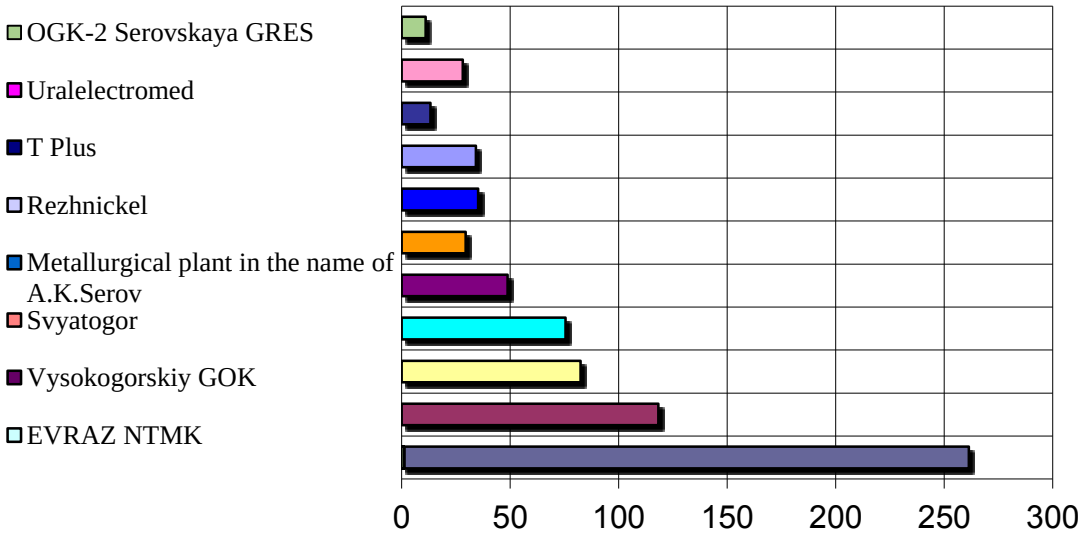

Figure 2. Emissions of the main polluting enterprises of atmospheric air, thousand tons/year

It should be noted that various environmental measures were carried out at the enterprises in order to minimize the negative impact of their activities on the environment in the Sverdlovsk region in 2016. The diagram (figure 3) shows methods of reducing emissions, which have been mostly used:

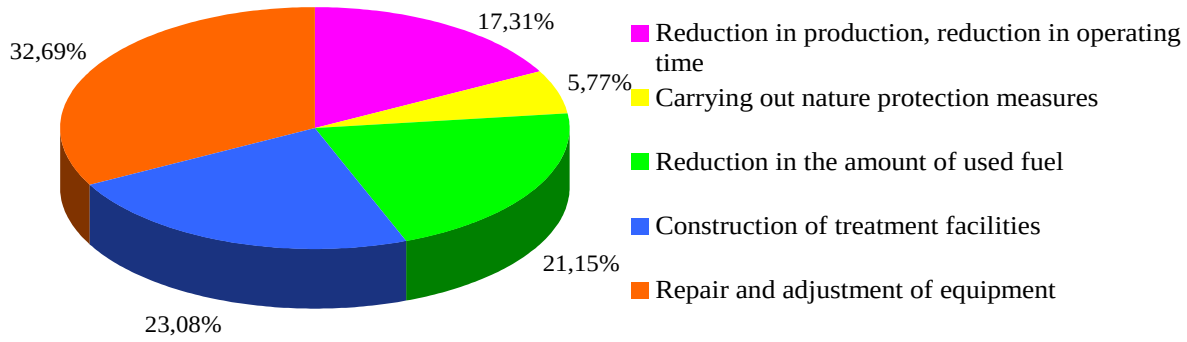

Figure 3. Environmental measures which are aimed at reducing emissions of pollutants

When we analyzed the information from the state report "On the state and protection of the environment of the Sverdlovsk region in 2015" it was established that 8,308.6 thousand tons of pollutants were formed from all sources of pollution in 2016. From this amount, 7,535.5 thousand tons were received from dust and gas treatment facilities. The average degree of pollutants catching in gas cleaning facilities was amounted to 89.1 %, including solids – 97.9 %, gaseous and liquid substances – 60.2 % [17]. Unfortunately, not all pollutants which were formed during the production process were supplied to dust and gas treatment facilities (figure 4).

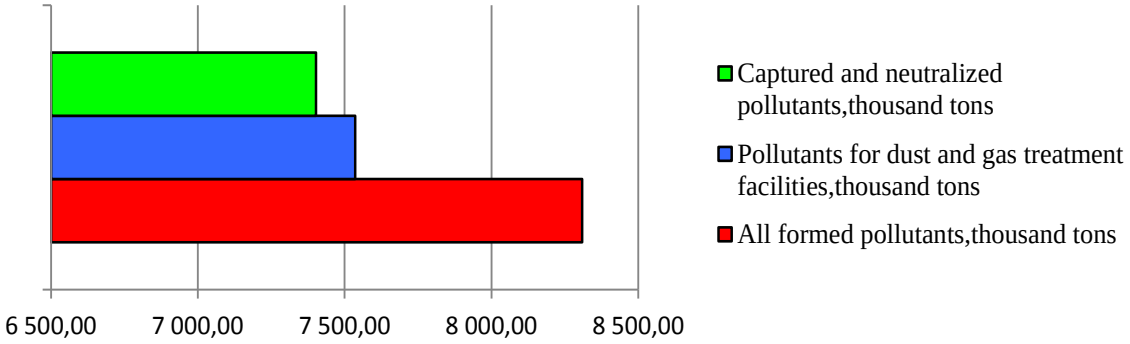

Figure 4. The amount of harmful substances which were cleaned in comparison to their total quantity

Therefore, even despite a sufficiently high level of exhaust gases purification, suspended substances with high toxicity, such as benzopyrene, as well as sulfur dioxide, nitrogen dioxides and formaldehyde, enter the atmosphere. Increased content of these substances in the air can cause an increase in the risk of diseases among the population [16]. This is confirmed by the results of research work on assessing the chemical risk for public health in 14 municipalities of the Sverdlovsk region, which has been conducted since 2003 [17].

3.2. Atmospheric pollution in Yekaterinburg

The next step of our work was the analysis of harmful substances content in the atmosphere of a large industrial center in the Sverdlovsk region namely Yekaterinburg and graphic processing of literary data (figures 5–7).

According to the results of observations in 2016, it was found that the level of atmospheric air pollution in the city, taking into account the value of the standard index (SI), should be classified as “high”. The concentrations of suspended particles, nitrogen dioxide, formaldehyde, benzopyrene and ammonia determined the value of the complex index of air pollution (IPA = 6). SI = 9.5

of ethylbenzene; the highest repeatability (HR) = 6 %. The level of air pollution also relates to a "high" category in assessing the level of formaldehyde TLV which was canceled in 2014, IPA = 8.

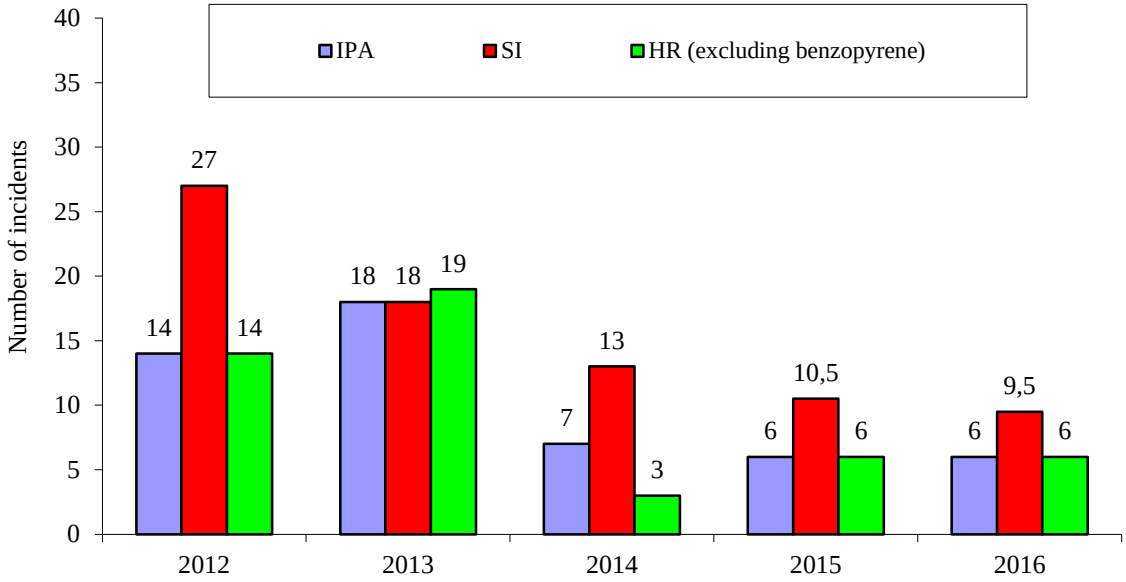

Figure 5. Dynamics of atmospheric pollution parameters in Yekaterinburg in the period 2012–2016

As we can see in figure 5, the level of atmospheric air pollution in the Yekaterinburg in 2012–2013 was "very high" and was determined by the values of complex IPA and SI parameter. In 2014–2016 the pollution level was decreased to "high" (according to the values of IPA and SI). For the period 2011–2013 in Yekaterinburg, the maximum repeatability was the repeatability of formaldehyde TLV and in 2014 was the repeatability of suspended substances. During the period 2012–2015 the SI parameter values were determined only by "very high" concentrations of ethylbenzene [17]. In 2016 the SI parameter value was decreased to "high".

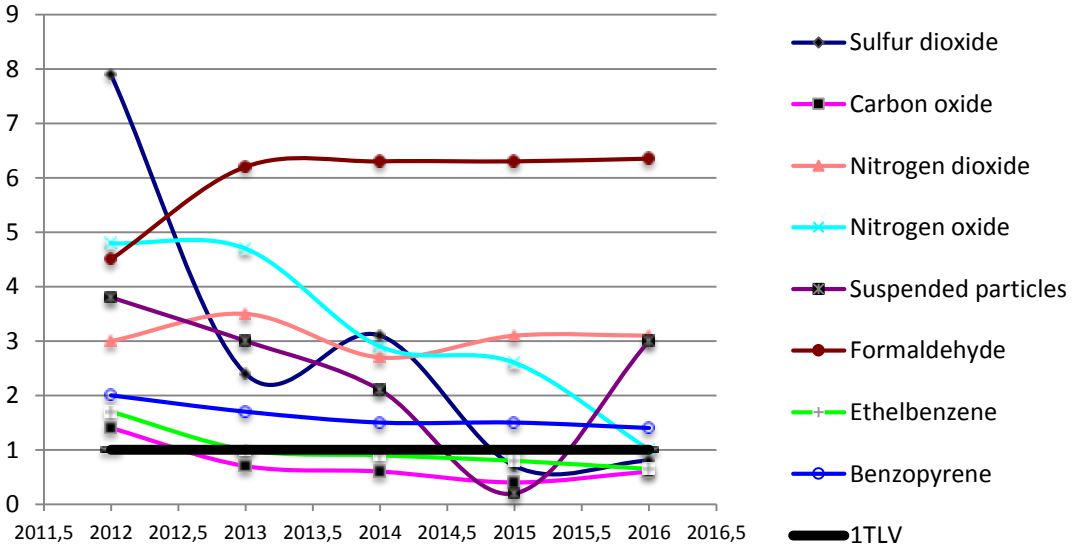

Figure 6. Maximum daily average concentrations of pollutants (in fractions of TLV)

Moreover, over the past five years the tendency to increase air pollution by suspended particles, nitrogen dioxide, phenol, benzene, and copper has been formed in the atmosphere of Yekaterinburg.

Basing on the data of automatic stations for the period 2012–2016, given in the official site [17], we constructed a diagram. As we can see, the level of air pollution in the city is "very high". This level exceeds several times the average daily threshold limit value (TLV) of the main pollutants (figure 6).

In 2016 the excess of nitrogen dioxides TLV was observed in 34.3 % of incidents, which corresponds to a high level of atmospheric air pollution by nitrogen dioxides. The maximum single concentration of nitrogen dioxides exceeded the established standards by 1.5 times. Moreover, the content of nitrogen oxide in the air increased by 3.1 times, and suspended particles – by 3 times.

3.3. The population morbidity

It should be noted that according to the WHO, 80 % of human diseases were caused by an environmentally unfavorable state of the environment and unsatisfactory living conditions in cities with large industrial enterprises. For the last 5 years the birth rate in Russia has fallen by 30 %, the death rate has increased by 15 %. 23 % of children remain healthy by the age of 7, and only 14 % – by the 17th anniversary. Since the 70s, the incidence of cardiovascular and oncological diseases has increased by 50 %. Children under the age of one die in Russia twice more often than in the United States. In some regions, more than a half of the children population suffers from the allergic diseases.

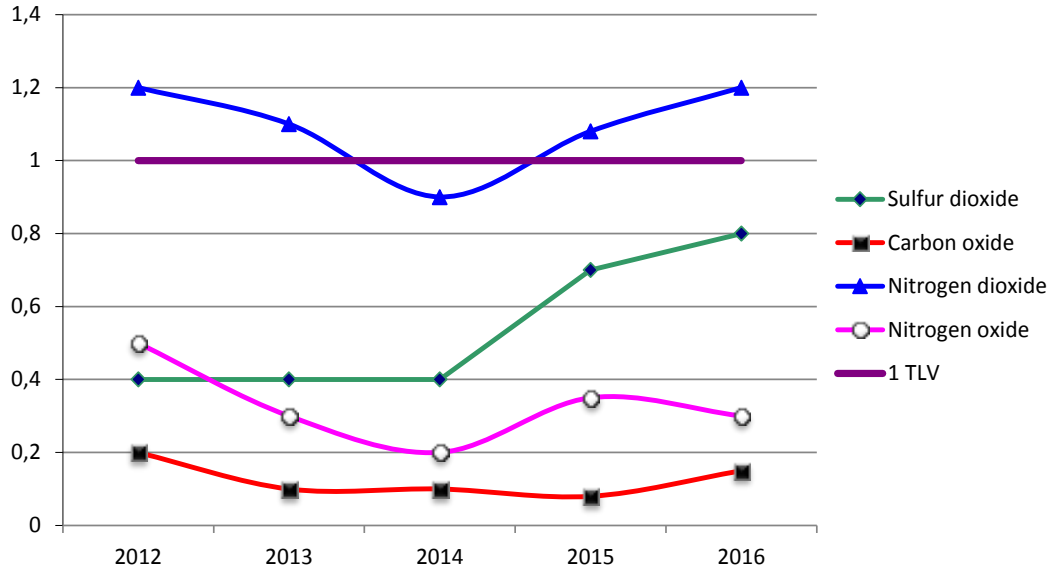

Figure 7. Average annual concentrations of pollutants in atmospheric air (in fractions of TLV) [17]

In this regard, the next step in our work was the analysis of the correlation between the growth in air pollution and the increase in the incidence of the population, based on the diagrams (figures 7 and 8).

We have found that if the level of contaminating substances is continuously increased in the atmosphere, in certain time, the population morbidity by individual types of diseases is increased.

We would like to note that in order to reduce the incidence of the population and to improve the ecological situation in the region, it is necessary to continue to strengthen measures not only to reduce, but also to prevent the formation of pollutant emissions into the atmosphere due to the development of low-waste and non-waste technologies. Moreover, people must pay special attention to their widespread implementation of these technologies in a large number of enterprises.

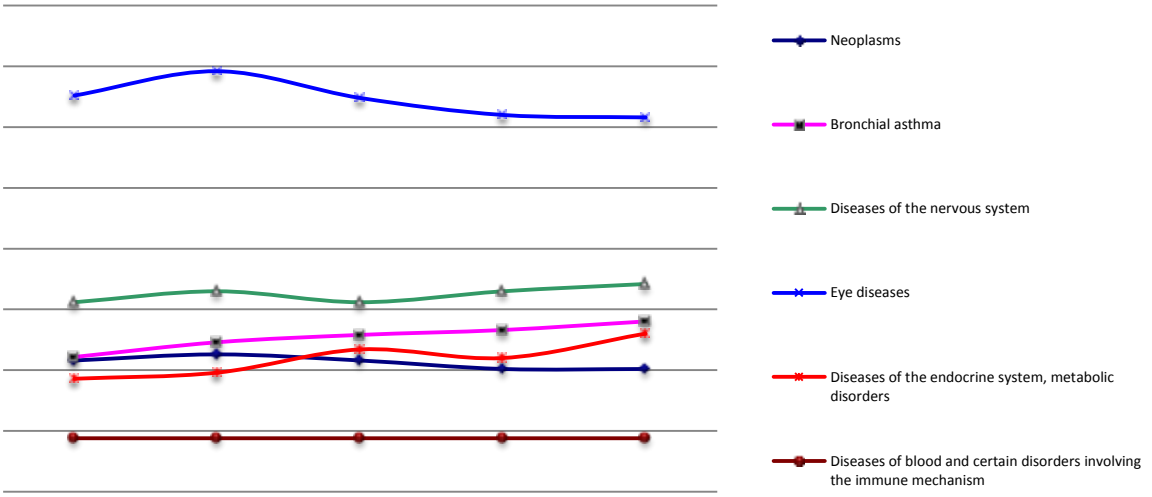

Figure 8. Dynamics of changes in the number of newly registered diseases per 1000 people [16, 18]

In addition, the creation of an environmental certification system for enterprises polluting the environment and equipping vehicles with exhaust gas neutralization systems can create a positive effect, since it is known that the contribution of road transport in air pollution in large cities reaches 90 %.

4. Conclusion

According to the results of observations during 2012–2016 the main stationary sources of pollution in the Sverdlovsk region are located in such cities as Yekaterinburg, Nizhny Tagil, Kamensk-Uralskiy, Pervouralsk etc. In this article we have investigated dynamics of pollutants' emission into the atmosphere by the industrial enterprises of Sverdlovsk region for the definition of population health effect. In 2016 (in comparison to 2015) emissions of pollutants into atmospheric air from stationary sources were decreased by 77.5 thousand tons (7.9 %), including solids – 33.9 thousand tons (20.4 %); emissions of liquid and gas-different substances – by 43.6 thousand tons (5.3 %), including reduction of emissions of sulfur dioxide – 28.9 thousand tons (10.9 %); nitrogen oxides – 10.4 thousand tons (7.1 %); volatile organic compounds – 1.2 thousand tons (10.8 %); hydrocarbons – 3 thousand tons (2.4 %), and carbon oxide – 0.6 thousand tons (0.2 %). However, over the past five years the tendency was formed to increase air pollution by suspended particles, nitrogen dioxides, phenol, benzene, and copper in the atmosphere of Yekaterinburg. Besides, we have found that if the level of contaminating substances is continuously increased in the atmosphere, in certain time, the population morbidity by individual types of diseases is increased.

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